EXPERIMENTAL ANALYSIS ON THE CONDENSER FINS FOR HOUSEHOLD REFRIGERATED SYSTEM

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ABSTRACT

An Experimental Analysis is done of the refrigerator condenser by varying the fins spacing of the condenser. vapour compression refrigeration system is a cycle in which domestic refrigerator works. it consist of compressor, condenser expansion valve and evaporator . The performance of the system depends on the performance of all the components of the system. The main objective of the present work is to increase the performance of the condenser by increasing the heat transfer rate through the condenser. Heat transfer rate can be increased by the extended surfaces called fins. Heat transfer rate is also depends on the spacing between the fins of the condenser.

Keywords— *COP,Discharge Pressure, Energy Consumption;*

INTRODUCTION

Refrigeration, the process of removing heat from an enclosed space or from a substance for the purpose of lowering the temperature. In the industrialized nations and affluent regions in the developing world, refrigeration is chiefly used to store foodstuffs at low temperatures, thus inhibiting the destructive action of bacteria, yeast, and mold. Many perishable products can be frozen, permitting them to be kept for months and even years with little loss in nutrition or flavor or change in appearance. Air-conditioning, the use of refrigeration for comfort cooling, has also become widespread in more developed nations Before mechanical refrigeration systems were introduced, ancient peoples, including the Greeks and Romans, cooled their food with ice transported from the mountains. Wealthy families made use of snow cellars, pits that were dug into the ground and insulated with wood and straw, to store the ice. In this manner, packed snow and ice could be preserved for months. Stored ice was the principal means of refrigeration until the beginning of the 20th century, and it is still used in some areas.

In India and Egypt evaporative cooling was employed. If a liquid is rapidly vaporized, it expands quickly. The rising molecules of vapour abruptly increase their kinetic energy. Much of this increase is drawn from the immediate surroundings of the vapour, which are therefore cooled. Thus, if water is placed in shallow trays during the cool tropical nights, its rapid evaporation can cause ice to form in the trays, even if the air does not fall below freezing temperatures. By controlling the conditions of evaporation, it is possible to form even large blocks of ice in this manner. Cooling caused by the rapid expansion of gases is the primary means of refrigeration today. The technique of evaporative cooling, as described heretofore, has been known for centuries, but the fundamental methods of mechanical refrigeration were only discovered in the middle of the 19th century. The first known artificial refrigeration was demonstrated by William Cullen at the University of Glasgow in 1748. Cullen let ethyl ether boil into a partial vacuum; he did not, however, use the result to any practical purpose. In 1805 an American inventor, Oliver Evans, designed the first refrigeration machine that used vapour instead of liquid. Evans never constructed his machine, but one similar to it was built by an American physician, John Gorrie, in 1844.

Commercial refrigeration is believed to have been initiated by an American businessman, Alexander C. Twinning, in 1856. Shortly afterward, an Australian, James Harrison, examined the refrigerators used by Gorrie and Twinning and introduced vapour-compression refrigeration to the brewing and meat-packing industries. A somewhat more complex system was developed by Ferdinand Carréof France in 1859. Unlike earlier vapour-compression machines, which used air as a coolant, Carré's equipment contained rapidly expanding ammonia. (Ammonia liquefies at a much lower temperature than water and is thus able to absorb more heat.) Carré's refrigerators were widely used, and vapour-compression refrigeration became, and still is, the most widely used method of cooling.

DOMESTIC REFRIGERATION SYSTEM:

The domestic refrigerator is one found in almost all the homes for storing food, vegetables, fruits, beverages, and much more. The parts of domestic refrigerator can be categorized into two categories: internal and external.

TYPES OF CONDENSER:

A. Natural Draft:

Some refrigerators primarily compact, single-door, and manual defrost models, have a natural draft condenser designed to dissipate heat being pulled from the refrigerator through normal room air flow. Natural draft models have the condenser on the back of the refrigerator. There is no fan motor under the refrigerator to aid in removing heat from the condenser.

B. Forced Air:

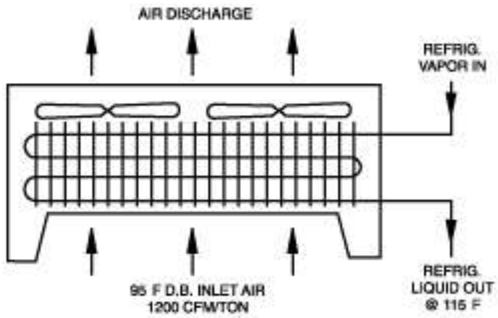
Many refrigerators have forced air condensers. Air is "forced" across the condenser coils by a condenser fan to aid in removal of the heat being pulled from the refrigerator. Forced air condensers are located under the refrigerator with a fan sitting to the side pulling cool air in from the right front of the refrigerator and exhausting the warm air out to the left front. This warm air is also passed over the drip pan to aid in evaporating the water accumulated from defrosting. As a general rule, automatic defrost models will have a forced air condenser.

C. Never clean Condenser:

On refrigerators, air is "forced" across the condenser coils by a condenser fan to aid in removal of the heat being pulled from the refrigerator during the cooling process. This movement of air collects dust and household debris which can affect cooling performance. Newer GE, GE Profile Series, and Cafe Series automatic defrost refrigerators have a Never clean Condenser. The condenser coils are located in the compressor housing instead of on the back, keeping them clean and functioning optimally. This design allows for more efficient airflow. The coils will not require cleaning under normal conditions.

D. Air cooled:

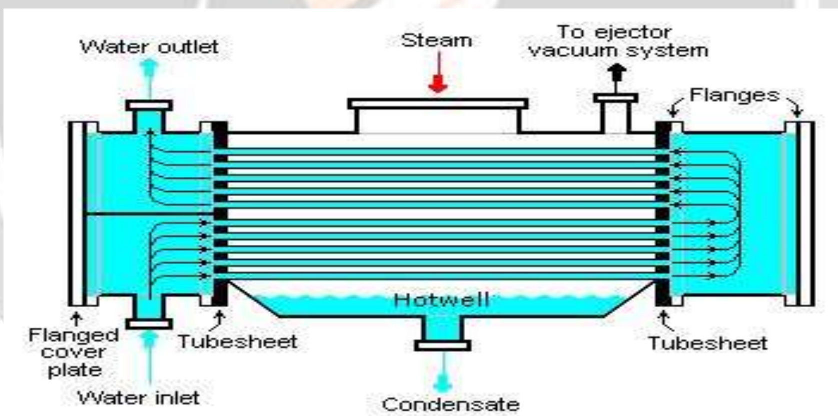
If the condenser is located on the outside of the unit, the air cooled condenser can provide the easiest arrangement. These types of condensers eject heat to the outdoors and are simple to install. Most common uses for this condenser are domestic refrigerators, upright freezers and in residential packaged air conditioning units. A great feature of the air cooled condenser is they are very easy to clean. Since dirt can cause serious issues with the condensers performance, it is highly recommended that these be kept clear of dirt.



Air cooled condenser

E. Water cooled:

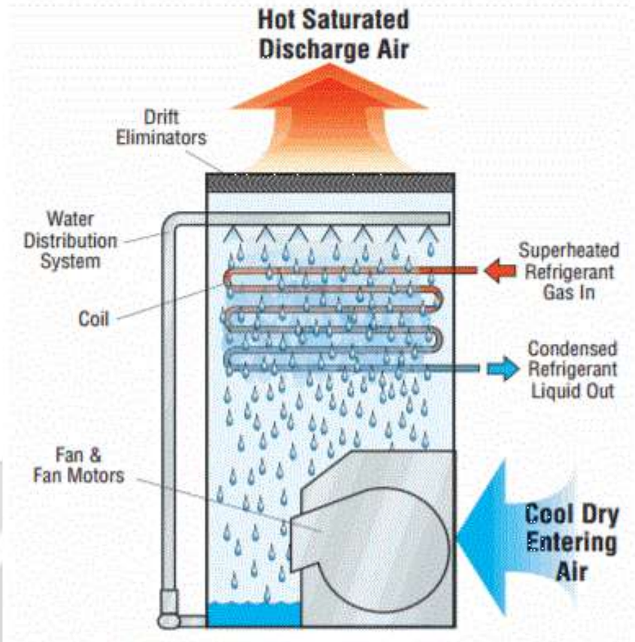
Although a little more pricey to install, these condensers are the more efficient type. Commonly used for swimming pools and condensers piped for city water flow, these condensers require regular service and maintenance. They also require a cooling tower to conserve water. To prevent corrosion and the forming of algae, water cooled condensers require a constant supply of makeup water along with water treatment. Depending on the application you can choose from tube in tube, shell and coil or shell and tube condensers. All are essentially made to produce the same outcome, but each in a different way.



water cooled heat exchanger

F. Evaporative:

While these remain the least popular choice, evaporative condensers can be used inside or outside of a building and under typical conditions, operate at a low condensing temperature. Typically these are used in large commercial air-conditioning units. Although effective, they are not necessarily the most efficient.



evaporative type heat exchanger.

G. **Expansion valve or capillary tube**:The refrigerant leaving the condenser enters the expansion devise, which is the capillary tube in case of the domestic refrigerators. The capillary is the thin copper tubing made up of number of turns of the copper coil. When the refrigerant is passed through the capillary its pressure and temperature drops down suddenly.

capillary tube of domestic refrigeration system.

H. **Evaporator or chiller or freezer:** The refrigerant at very low pressure and temperature enters the evaporator or the freezer. The evaporator is the heat exchanger made up of several turns of copper or aluminum tubing. In domestic refrigerators the plate types of evaporator is used as shown in the figure above. The refrigerant absorbs the heat from the substance to be cooled in the evaporator, gets evaporated and it then sucked by the compressor. This cycle keeps on repeating.

domestic refrigerator evaporator

I. **Temperature control devise or thermostat**: To control the temperature inside the refrigerator there is thermostat, whose sensor is connected to the evaporator. The thermostat setting can be done by the round knob inside the refrigerator compartment. When the set temperature is reached inside the refrigerator the thermostat stops the electric supply to the compressor and compressor stops and when the temperature falls below certain level it restarts the supply to the compressor.

J. **Defrost system**: The defrost system of the refrigerator helps removing the excess ice from the surface of the evaporator. The defrost system can be operated manually by the thermostat button or there is automatic system comprising of the electric heater and the timer.

LITERATURE REVIEW

S.Sharmas Vali et al (2011) This paper describes the Experimental Analysis of performance of the refrigerator condenser by varying the fins spacing of the condenser. Vapor compression machine is a refrigerator in which the heat removed from the cold by evaporation of the refrigerant is given a thermal potential so that it can gravitate to a natural sink by compressing the vapor produced. Majority of the refrigerators works on the Vapor compression refrigeration system. The system consists of components like compressor, condenser, expansion valve and evaporator. The performance of the system depends on the performance of all the components of the system. The main objective of the present work is to increase the performance of the condenser by increasing the heat transfer rate through the condenser. Heat transfer rate can be increased by the extended surfaces called fins. Heat transfer rate is also depends on the spacing between the fins of the condenser. In the present experimental work several condensers having different fins spacing are taken. By using this parameter experiments are conducted on a domestic refrigerator of capacity 165liters. The effect of varying the condenser fins spacing on the performance of refrigerator condenser is calculated experimentally.

G. Kiran Kumar (2011) A refrigerator is a machine which attains and maintains the temperature of a space below that of surroundings by transferring heat from the space to be cooled to the surroundings with the help of a compressor. Majority of the refrigerators works on the vapor compression refrigeration system which consists of components like compressors, condensers, expansion valve and evaporator. The performance of the system depends on the performance of all the components of the system. A condenser is a heat exchanger where the refrigerant is first desuperheated and then the saturated vapor condenses into liquid state. This is an important part of the refrigeration cycle without which the refrigerant cannot be recycled. In general all the domestic refrigerators have naturally air cooled condensers. Heat transfer from such condensers can be increased by the extended surfaces called fins. The rate of heat transfer through condenser depends on fin material, spacing between the fins, geometry of the fins and it‘s thermal conductivity. This experimental work focuses on the effect of condenser fin geometry on the performance of the condenser. Experiments are conducted with circular and rectangular cross sectional fins fabricated to the condenser of 165 lts capacity refrigerator. Heat transfer rate through the condenser is calculated for different fin geometries.

Chandrashekhar M. Bagade et al (2012) Day by day there is increasing demand of refrigerating effect which increases the load on compressor. But sub cooling and superheating are the process used for getting maximum refrigerating effect, ultimately improve COP of the refrigerating system. Condenser plays an important role in any refrigeration system .it is use to remove heat from refrigerant vapour coming from compressor p-h and T-s diagrams clearly shows, the effect of sub cooling after condensate formation on COP. Now a day we are interested in improving COP of refrigeration system, without affecting compressor work. Sub cooling is one of the factors that can improve the COP of refrigeration system. Sub cooling is done in the condenser, thus condenser design is the key factor to improve the COP of domestic refrigerator.

P. Sarat Babu et al (2013) The condenser design plays a very important role in the performance of a vapour compression refrigeration system. Optimized design is possible through theoretical calculations, however may fail due to the reason that the uncertainties in the formulation of heat transfer from the refrigerant inside the condenser tubes to the ambient air. Hence experimental investigations are the best in terms of optimization of certain design parameters. In my experimental work, it is proposed to optimize condenser length for domestic refrigerator of 165 litres capacity. It may give a chance to find a different length other than existing length will give better performance and concluded that the optimum length of coil is 7.01m.

In the present work, the length of the condenser is optimized for a vapour compression refrigeration system used for a domestic refrigeration of 165 Litres capacities, through experimental investigation. Theoretical computation are also made and compared and found that the optimum length of coil is 7.01 m instead of standard value 6.1m.

P. Saji Raveendran et al (2013) In view of Kyoto protocol, there is a pressing need to reduce the energy consumption and environmental impacts of domestic appliances. In the total energy consumption of household appliances, domestic refrigerator plays a vital role. Alternate refrigerants and improvement in the performance of the components can contribute to tackle the above issue in a domestic refrigeration system. In this paper, the performance of a domestic refrigeration system with brazed plate heat exchanger as condenser, and working with refrigerants such as R290/R600a and R134a was studied using experimental method. The result showed that the system with water-cooled brazed plate heat exchanger reduces the per day energy consumption of a system from 21% to 27% and increases the COP from 52% to 68%, when compared to conventional system. The compressor discharge temperature and dome temperature are also dampened. For R134a and R290/R600a, the TEWI of the system with water-cooled brazed plate heat exchanger is lower than that of the system with air-cooled condenser by 26.8% and 21%, respectively. Among the refrigerants, R290/R600a showed higher performance than R134a.

Sreejith K (2014) The objective of this paper was to investigate experimentally the effect of different types of compressor oil in a domestic refrigerator having water cooled condenser. The experiment was done using HFC134a as the refrigerant , Polyol-ester oil (POE) oil which is used as the conventional lubricant in the domestic refrigerator and SUNISO 3GS mineral oil as the lubricant alternatively. The performance of the domestic refrigerator and HFC134a/POE oil system was compared with HFC134a/SUNISO 3GS mineral oil system for different load conditions. The result indicates that the refrigerator performance had improved when HFC134a/SUNISO 3GS mineral oil system was used instead of HFC134a/POE oil system on all load conditions. The HFC134a/SUNISO 3GS mineral oil works normally and safely in the refrigerator. HFC134a/SUNISO 3GS mineral oil system reduced the energy consumption when compared with the HFC134a/POE oil system between 8% and 11% for various load conditions. There was also an enhancement in coefficient of performance (COP) when SUNISO 3GS mineral oil was used instead of POE oil as the lubricant. The water cooled heat exchanger was designed and the system was modified by retrofitting it, instead of the conventional air-cooled condenser by making a bypass line and thus the system can be utilized as a waste heat recovery unit. The hot water obtained can be utilized for household applications like cleaning, dish washing, laundry, bathing etc. Experimental result shows that about 200 litres of hot water at a temperature of about 58ºC over a day can be generated and thus the system signifies the economic importance from the energy saving point of view.

INSTRUMENTATION AND EXPERIMENTAL SETUP

Instruments and refrigerator used

- SINGLE DOOR LG REFRIGERATOR OF 185L.
- TWO PRESSURE GAUGES.
- DIGITAL CLAMP METER.
- 14 DIGITAL SENSORS.
- REFRIGERANTS (R-134a AND R-404A)
- FILTER AND INSULATING TAPE.

Specification of Refrigerator

1	Manufactured By	LG Electronics India Pvt.Ltd.
2	Model	Gl-195RL4
3	Net Weight	35 Kg.
4	Gross Capacity	185L
5	Net Dimensions (In Mm) (WxDxH)	538x634x1147
6	Voltage	220V-240V
7	Frequency	50Hz
8	Compressor	Reciprocating
9	Condenser	Air-Cooled
10	Working Refrigerant	R-134a

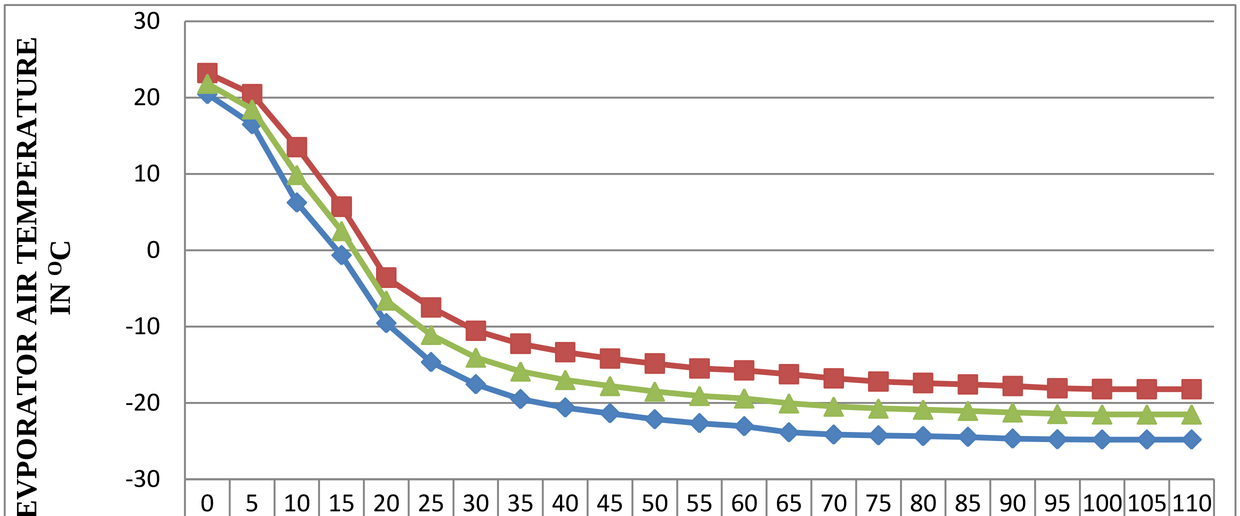
physical and technical specification of the refrigerator

Experimental setup

To perform the experiment 185L refrigerator is selected which was designed to work with R-134a,it is consists of an evaporator, air cooled condenser, reciprocating compressor. The refrigerator was instrumented with two pressure gauges at inlet and outlet of the compressor. The temperature at four different points is taken by 8 digital sensors, for measuring temperature on food compartment and freezer compartment 5 sensors are fitted, current and volt of the refrigerator is measured by digital clamp meter.

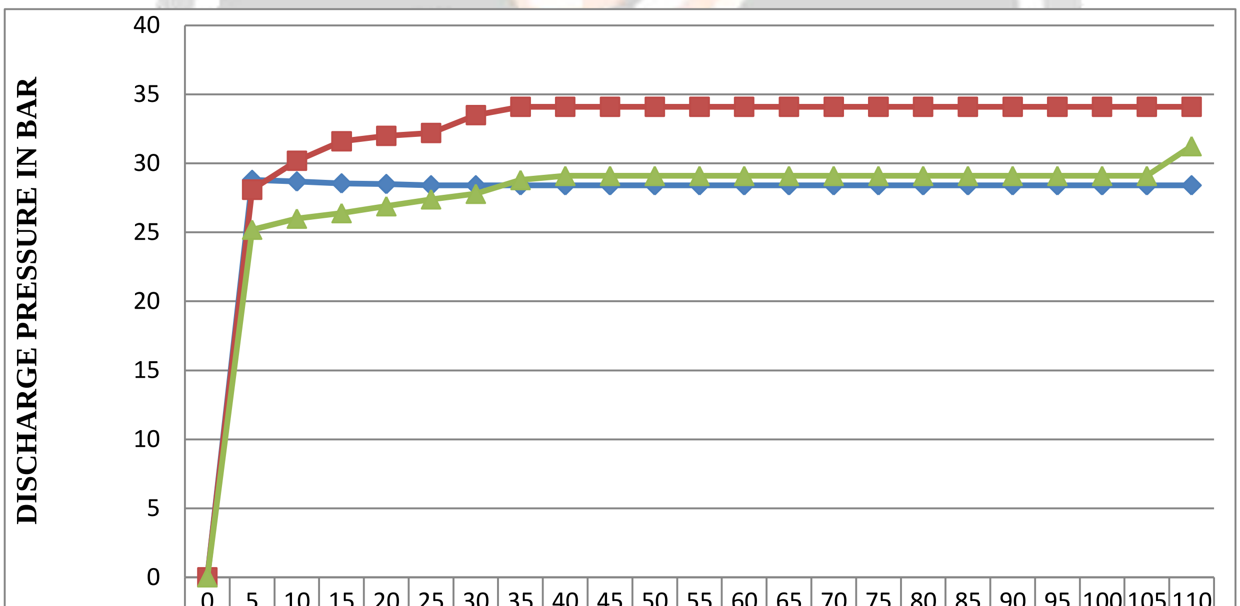
experimented 185l LG refrigerator

RESULTS AND DISCUSSION



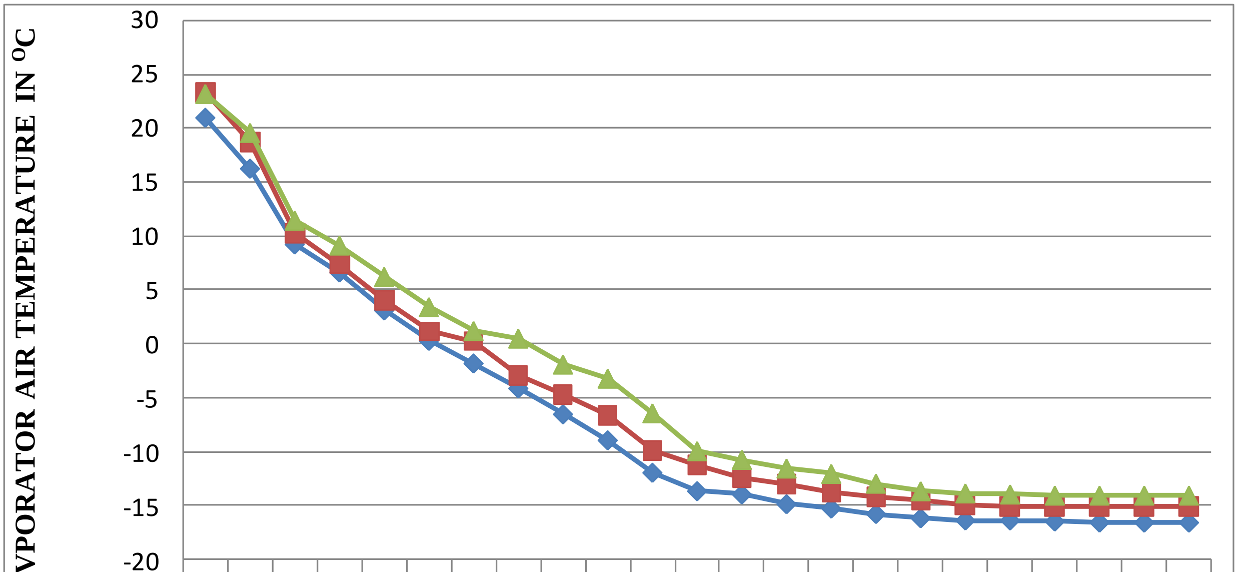
	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110
4 mm	20	17	6.	-1	-1	-1	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2
6 mm	23	20	13	5.	-3	-7	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
8mm	21	18	9.	2.	-6	-1	-1	-1	-1	-1	-1	-1	-1	-2	-2	-2	-2	-2	-2	-2	-2	-2	-2

PULL-DOWN TIME FOR 4MM, 6MM & 8MM CONDENSER SPACING.



	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110
4 mm	0	29	29	29	29	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28	28
6 mm	0	28	30	31	32	32	33	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34	34
8mm	0	25	26	26	26	27	27	28	29	29	29	29	29	29	29	29	29	29	29	29	29	29	31

2DISCHARGE PRESSURE FOR 4MM, 6MM AND 8MM CONDENSER SPACING.



	0	5	10	15	20	25	30	35	40	45	50	55	60	65	70	75	80	85	90	95	100	105	110
4 mm	21	16	9.	6.	3.	0.	-2	-4	-7	-9	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
6 mm	23	19	10	7.	4.	1.	0.	-3	-5	-7	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1
8mm	23	20	11	9.	6.	3.	1.	0.	-2	-3	-6	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1	-1

Capillary tube outlet temperatures FOR 4MM, 6MM AND 8MM CONDENSER SPACING.

CONCLUSIONS

After the successful investigation on the performances of refrigerator with different condenser spacing, the following conclusions can be drawn based on the results obtained:

❖ **Pull down time of refrigerator.**

- Pull down time at 4mm was 10.05% (5) minute earlier than at 6mm.
- Pull down time at 4mm was 13.32% (10) minute earlier than at 8mm.
- Pull down time at 6mm was 10.52% (5) minute earlier than at 8 mm.

❖ **Energy consumption of refrigerator.**

- 8mm condenser spacing offers lowest energy consumption. The compressor Consumes 2.22% & 3.12% less energy when 4 mm and 6mm condenser spacing was used in the system, respectively.

❖ **COP of refrigerator.**

- Overall average COP of 4mm condenser spacing was 4.43% & 4.47% higher than the 6mm & 8 mm condenser spacing

❖ **Discharge pressure of refrigerator.**

- Discharge pressure of 4mm condenser spacing was less with that of 6mm & 8mm condenser spacing with average percentage reduction of 14.23% & 15.83%

Thus, it is concluded that condenser with 4mm spacing is preferable, and safe viable for domestic and small commercial refrigeration systems with the main advantage that it can be replaced directly without the need to replace or modify any system component.

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